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SiO Overcoating and Polishing of CFRP Telescope Panels

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Our work on the development of carbon fiber reinforced plastic (CFRP) panel overcoating and polishing is structured in two parts. The first part utilized a short series of experiments to determine the feasibility of overcoating and polishing CFRP panels, and the second part will employ a systematic approach to optimize techniques learned. The initial work has been completed successfully and is the primary topic of this paper.

Questions which required answers in our initial investigation are summarized below:

1. Will silicon monoxide (SiO) bond well to CFRP?
2. Will the coating hold up under temperature cycling?
3. Can suitable coating rates and thicknesses be achieved?
4. Can a panel withstand the temperatures in a coating chamber?
5. Can large mirrors be coated?
6. How is the optical performance of a coated panel affected by thermal deformations?
7. Will the coating create any bimetal surface effects?
8. Will films remain bonded during polishing?
9. What is the effect of polishing a hard substance on a soft substrate?

Tests were performed in the Steward Observatory's 2.2 Meter Vacuum Coating Chamber, which employs evaporation sources symmetrically placed on rings beneath the mirror, with a glow discharge for plasma cleaning. For the SiO deposition, open tantalum boats were filled with SiO and heated using embedded tungsten coils.

Tests began with 3 cm square pieces of CFRP facesheet material. A deposition of 0.2 μm, which is typical of protective overcoatings for astronomical mirrors, bonded well and was abrasion resistant. A deposition of 4.0 μm could be machine polished for several hours without debonding the coating.

Next, a 10 cm square and one-inch-thick CFPR-Aluminum core panel was tested. The panel was coated to 12.5 μm thickness in about five hours. No visible coating deterioration was noticed during rapid temperature cycling (between +40°C and -70°C), and machine polishing resulted in noticeable improvement. It was, however, noticed during polishing that the mirror had warped significantly. This was attributed to the >80°C substrate temperature measured during the SiO deposition. The coating temperature was therefore reduced to 50°C, typical of what might be expected during shipping in Arizona in summer.

Tests were then conducted on a 0.5-meter-square Dornier panel (QUAD 4) with CFRP facesheets on two-inch aluminum Flexcore. The panel had a 10-meter radius of curvature. Using

the Steward Chamber in its normal configuration with 12 deposition boats caused the 50°C temperature limit to be exceeded before any significant coating could take place. Switching to only 2 boats, however, achieved the desired deposition rate and thickness, and the temperature stayed well below the 50°C limit. This panel was then used to test various hand polishing techniques. A pitch tool with 1-3 μm diamond dust produced the best compromise between polishing time and mirror finish.

To complete the initial study, a previously characterized 0.5 m Dornier panel (QUAD 23) was coated and hand polished (until breakthrough started to occur). FIGURE 1 illustrates the before and after panel figure errors relative to a surface expressed as Zernike polynomials. As is clearly seen, the focus and large astigmatism follow the previous "as replicated" data. The mirror's optical performance was not affected by the SiO coating. It is important to note that the temperature cycling did not damage the polished coating of this panel, even though distortions in excess of 30 μm were experienced.

With the success of this initial program, work is now beginning on the optimization phase in conjunction with the JPL panel development program. A dedicated vacuum chamber has been built to work with panels as large as 50 cm. For larger panels (up to 2 m), the Steward Chamber will be used. Tests will be conducted on new evaporation sources, heat shielding, and the like to optimize the coating process. The work will concentrate on polishing to optical specifications.

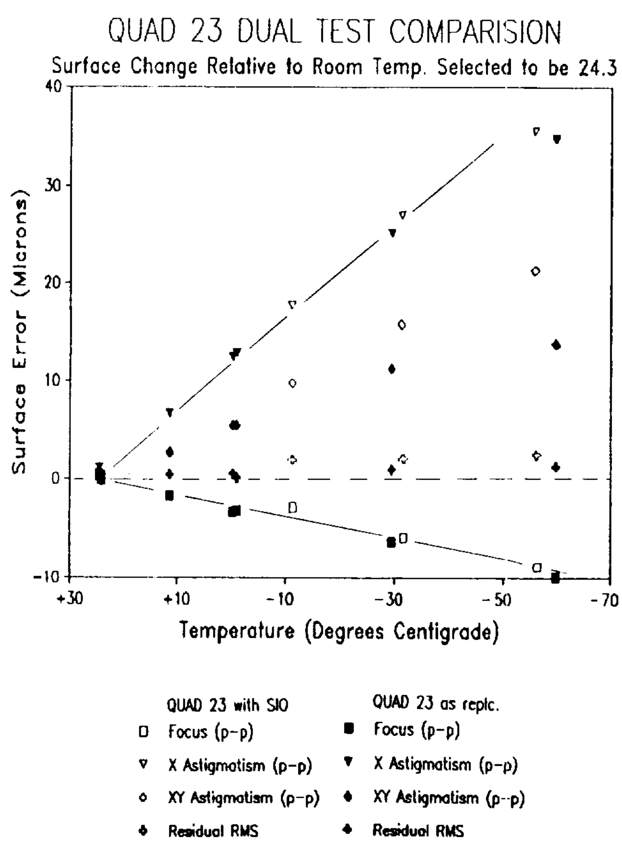

FIGURE 1. Panel Comparison Tests Before and After SiO Coating